African Journal of Environmental and Waste Management Vol. 1 (5), pp. 096-100, December, 2013. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research paper

Public health implications of using water from wells located near municipal waste dump sites in parts of Zaria

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Accepted 19 May, 2013

This study aimed at determining the contamination level and seasonal distribution of pathogens in well water located near municipal solid and liquid wastes. A total of 186 samples of well water, soil from dumpsites and liquid waste close to sampling wells were obtained from parts of Zaria. The samples were examined using standard procedures. Total plate count, coliform count determinations were done for two seasons. The mean coliform count in the study are 4.66±3.8 for wells near solid and liquid waste, 4.54±3.6 for wells near solid waste and 4.64±3.9 for wells near liquid waste. The entire well water sample had coliform counts higher than recommended standard for drinking water. The numbers in all cases were higher in the wet seasons.

Key words: Public health, municipal waste dumps, well water.

INTRODUCTION

Surface fresh water is widely used as source of drinking water worldwide. Over one billion people lack access to safe drinking water, increasing the vulnerability to diarrhoea and parasitic diseases. On a global scale 25,000 people die each day as a result of poor water quality and water related diseases such as cholera and diarrhoea. Typhoid represents the single largest cause of human morbidity and mortality (Schram, 1972; Pruess et al., 1999; WHO, 1999; Stewart-Tull, 2001).

Like many developing nations, Nigeria has a high population density (>120 million) with a relatively poor infrastructure especially in urban centers. Available sanitary facilities cannot sustain the population and reckless waste disposal could lead to contamination of surface water with faecal materials. World wide, contaminated water causes an estimated 6 to 60 billion cases of gastrointestinal illness annually, majority of which occur in rural areas of developing nations where water supply is polluted with a variety of microorganisms, and adequate sanitation is unavailable (Laurie et al., 2004). The solid and liquid waste management could be a source of risk, either to workers directly involved or to nearby residents. The health risks from waste are caused by factors including the nature of raw waste, waste decomposition, handling and disposal of wastes. Environmental health risks to residents are due to prolonged exposure time.

Solid waste composition is largely affected by income generating activities in the country as well as level of industrialization. The income level affects the main ingredients in the solid waste, particularly the level of packaging that is (paper, plastic, cartons, cans, bottles). Hazardous materials in solid waste include, syringe, blood contaminated materials, and other infectious medical wastes such as blood contaminated bandages, cotton swabs, etc, are commonly found mixed with municipal solid waste collected in developing countries (Barrera and Navarro, 1995; Kerrison, 1997); and in countries where more than 30% of the industrial waste were appropriately discharged to open dumps (De Koning et al., 1994).

Human faecal matter is common in solid wastes, in the poorest countries, because of poverty of sanitation systems, people defecate along roadside ways and on

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open lots, night soil is deposited in open drains, and waste resulting from street and drain cleaning contain faeces. Homes where buckets or bedpans are used, the human waste is often packed in plastic bags or wrapped in Newspapers before discarding with the solid waste. Waste picking is high risk because tuberculosis, bronchitis, asthma, dysentery, parasites and malnutrition are most commonly experienced among waste pickers based on health studies of waste pickers conducted in Bangalore, Manohar, and New Delhi, India (Huisman, 1994). At metro Manilas main open dump, in 1981, 750 waste pickers studied revealed that 40% had skin disease and 70% had upper respiratory diseases. Health data 1994 was reviewed for the Accra Municipal Solid Waste Department and compared with local construction company, the number of people reporting sick (year 1994 already mentioned above) during the year was 47.6% of the total solid waste staff, compared to 33% of the construction company. Increase in overall incidence in some developing countries has been studied. Data from Ghana shows a dramatic increase in enteric fever, tuberculosis and malaria over the 1970 to 1995 period (Cointreau, 2003). In Nigeria and other developing countries, the vulnerability of surface water bodies to pollution (by animals, wastes, sewage and storm water runoffs, which contain decomposable organic matter and pathogenic agents) is high. The use of raw/treated wastewater for irrigation was found to constitute serious public health risk (Umoh et al., 2001; Okafo et al., 2003). Diarrhea is still one of the leading causes of death among children under five in developing countries. Cholera caused severe pandemics in developing countries due to poor sanitation, water shortage and natural disasters like floods and wars (Stewart –Tull, 2001; Hunter, 2003). Outbreaks of cholera during the 1990's in Conakry, Guinea occurred largely within communities where faecal contamination of wells was high. The first report of classical cholera in Nigeria was the 1970 and 1971 epidemics affecting Lagos, the Mid-west States, Kano and Zaria (Schram, 1972). More recently epidemics are frequently reported in overcrowded Nigerian cities including Lagos and Kano due to water shortage, deterioration of sanitary conditions and ingestion of contaminated water or food (Agbogu, 2004). The waste management unit of the World Health Organization has recommended to support studies that would provide more insight on the magnitude of the health and safety problems in developing countries and their causes.

Nigeria has a high population density with a relatively poor infrastructure, available sanitary facilities cannot sustain population leading to waste being scattered all around and could be washed in wells as run offs. Many out breaks have been reported as result of this. Significant risks to human may occur from exposure to pathogens in well water from which drinking water is derived (Adeyeba and Akinbo, 2003). Zaria metropolis does not have a major waste treatment plant except the one provided by the Ahmadu Bello University, Zaria for the treatment of sewage generated within the University and its immediate environment. The objective of this work is to study the level and occurrence of target pathogens in well water and municipal wastes (liquid/solid).

MATERIALS AND METHODS

Study areas

The two urban settlements studied were Sabon Gari and "Zaria city" both in Zaria. Zaria is located on a plateau at a height of about 2200 feet above sea level in the centre of Northern Nigeria and more than 400 miles away from the sea. Zaria (11° 3^1 N, 70 42^1 E) possesses a tropical continental climate. The tropical climate is more pronounced during the dry season, especially in December and January. The mean daily maximum temperature shows a peak in April and a minor one in October. Zaria lies within a region which has a tropical savanna climate with distinct wet and dry seasons. The tropical annual rainfall in Zaria is not high (Mean is about 44.4 inches). The vegetation of the area assumes various shades of green in wet season and turns brown, pale or yellow in the dry season (Mortimore, 1970) (Figure 1).

Collection of samples

Well water samples

Sterile 250 ml bottles were used in collecting representative water samples from wells using the container (guga) locally made and used in fetching water from the wells. Water collected were sealed, and placed in a cooler with ice then transported to the laboratory for analysis within 6 h of collection. All samples were collected between 8.30 and 10.30 am; and analyzed at the postgraduate laboratory, Department of Microbiology, and the Department of Water Resources and Environmental Engineering, Ahmadu Bello University, Zaria.

Solid waste samples

The surface soils were collected from waste dumpsites located near wells (W1 to W16), using sterile stainless spoon to a depth of 3 cm into a sterile polythene bags. Samples were transported in a cold pack to the laboratory for analysis that was carried out within 6 hour of collection.

Liquid waste samples

A sterile 250 ml bottle was dipped gently against the liquid flow and samples collected were covered gently and placed in a cooler with ice and transported to the laboratory for analysis within 6 h of collections.

Determination of total plate count and coliform counts

For total plate count, serial dilutions of water samples (well water and liquid waste) were made using cotton plugged tubes, each containing 9 ml sterile distilled water. Using a sterile pipette, 1 ml of well-mixed sample was added to tube 1. This was shaken to mix properly and with another sterile pipette, 1 ml was dispensed into tube 2. This mix- and dispense process continued till the third tube

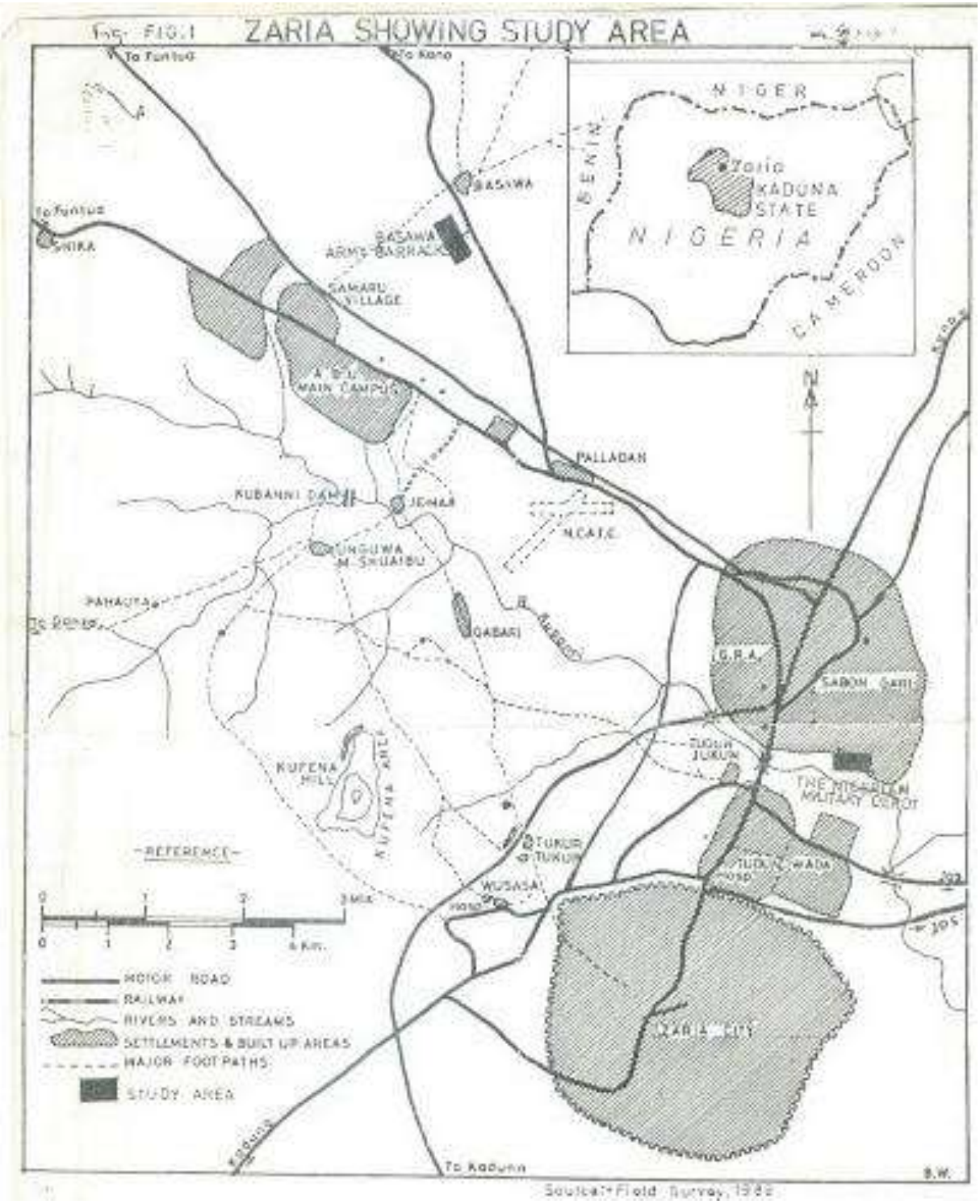

Figure 1. Map of study showing sampling areas.

(for dry season samples) and sixth tube (for wet season samples), from which 1 ml was discarded, to obtain 10^{0}-10^{-6} dilutions. The last two dilutions (10^{-2}, 10^{-3} for dry season samples and 10^{5}, 10^{-6} for wet season samples) were inoculated in duplicates by pour plating method. Total plate count was done on total plate count agar and incubated at 37°C for 24 h. Total coliform count was done on Eosin methylene blue agar (EMB) and incubated at 37°C for 24 h. About 25 g of soil sample collected was weighed into 225 ml of sterile distilled water and further diluted serially as described earlier. The last two dilutions were plated out in duplicates using the pour

Table 1. Mean of coliform counts of well water from different sites and location.

	Mean counts log_{10} cfu.	
Sample locations	**Sampling site n=6 each**	**Mean*± std**
Zaria city	W1	4.28^{b} ± 3.1
	W2	4.25^{b} ± 2.8
	W3	4.51^{b} ± 3.3
	W4	4.27^{b} ± 3.4
	W5	4.27^{b} ± 3.3
	W6	4.30^{b} ± 3.4
	W7	4.33^{b} ± 3.3
	W8	2.61^{a} ± 1.2
Sabon Gari	W9	4.21^{b} ± 3.1
	W10	4.23^{b} ± 3.3
	W11	4.17^{b} ± 3.3
	W12	4.31^{b} ± 3.4
	W13	4.16^{b} ± 3.0
	W14	4.24^{b} ± 3.2
	W15	4.33^{b} ± 3.2
	W16	2.16^{a} ± 1.1

W1= Well water from sampling well * means with different superscript are significantly different ($p<0.05$) using Duncan's multiple range test. WHO permissible level for drinking water is100 cfu/ml.

Table 2. Comparison of the mean of controls wells with other well types, soils from waste dumps and liquid waste for 6 months.

Sites	**Total plate counts (log_{10} cfu/ml) mean S.E**	**Total coliform counts (log_{10} cfu/ml) mean S.E**
Wells near solid and liquid waste	$6.94±6.1^{b}$	$4.66±3.8^{b}$
Wells near solid waste	$7.20±6.0^{b}$	$4.54±3.6^{b}$
Wells near liquid waste	$6.92±6.2^{b}$	$4.64±3.9^{b}$
Solid waste	--	$5.93±5.1^{c}$
Liquid waste	--	$5.90±5.4^{c}$
Control	$4.85±4.2^{a}$	$3.92±3.4^{a}$

P<0.005 (.0001), P<0.005 (0.0021), (abc) = each sample type mean counts with different superscripts are significantly different. ($p<0.05$) using the students t-test. ± =standard error. (--) = no sample types present.

plating method. Total plate count was done on total plate count agar and incubated at 37°C for 24 h. Total coliform count was done on EMB at 37°C for 24 h.

RESULTS AND DISCUSSION

Table 1 shows the range of counts, mean and the median of the total pate and total coliform counts from different sampling sites and locations. Comparing the mean of counts from the different water samples studied the results showed that the mean values for the water samples were higher than the recommended 100 cfu/ml for drinking water. However, there was no significant difference between the counts for wells from the two locations ($p>0.05$). Table 2 shows the results of comparison of the mean total of the controls with the well types, soil and liquid waste samples for six months. The results show a significant difference ($p<0.05$ between well waters, soil samples and liquid waste and the control. In comparing the mean values of total plate and total coliform counts by location, Sabon Gari samples did not show any significant difference from Zaria City samples. Table 3 reveals the variation in the microbial counts for both seasons. This study was carried out over a period of six months (February to July, 2007). The first three months had no rain falls while the last three months had rain fall at regular intervals, and the laboratory results showed that rain falls had a significant effect on bacterial counts. In comparing the total pate counts and the total coliform counts for both wet and dry seasons, there is a significant difference between the dry and the wet seasons ($p<0.05$).

Table 3. The variation in total plate counts and total coliform counts of water obtained from wells located near solids and liquid waste

Well type	Sampling site n=6 each	Mean TPC (log_{10} cfu/ml)		Mean TCC (log_{10} cfu/ml)	
		Dry mean S.E	Wet mean S.E	Dry mean S.E	Wet mean S.E
Wells near solid and liquid waste.	W1	5.30± 3.4 [b]	7.25± 3.6	3.60 ± 2.9[b]	4.97± 3.3
	W4	5.36± 3.0 [b]	7.11± 3.0	3.67± 2.8[b]	4.87± 3.6
	W7	5.34± 3.1[b]	7.17± 3.5	3.73± 3.0[b]	4.92± 3.4
	W12	5.31± 3.4 [b]	7.37± 3.8	3.65± 2.9[b]	4.97± 2.8
Well near solid waste dump site.	W5	5.30±3.1[b]	7.14± 3.0	3.63± 2.6 [b]	4.90± 3.3
	W6	5.33±3.5[b]	7.20± 3.0	3.77± 2.9 [b]	4.82± 3.7
	W9	5.26±3.3[b]	7.38± 3.1	3.67± 2.8 [b]	4.76± 3.7
	W10	5.30±3.2 [b]	7.40± 3.0	3.66± 2.7 [b]	4.81± 3.7
	W11	5.29± 3.5 [b]	7.32± 3.9	3.57± 2.3 [b]	4.76± 3.7
	W13	5.38±3.3[b]	7.30± 3.5	3.69± 2.9 [b]	4.62± 3.6
	W14	5.32±3.6 [b]	7.38± 3.0	3.68± 2.8 [b]	4.79± 3.7
	W15	5.32± 3.3 [b]	6.32± 3.8	3.74± 2.3[b]	4.92± 3.8
Wells near liquid waste.	W2	5.37± 3.4 [b]	7.25± 3.7	3.65 ± 2.8[b]	4.85 ±3.7
	W3	5.32± 3.5[b]	7.17± 3.4	4.07 ±3.9[b]	4.95±3.9
Controls	W8	3.96± 2.7[a]	4.76± 3.6	2.13± 1.7[a]	3.54.±2.3
	W16	4.03±3.1[a]	5.31± 3.9	2.12±1.2[a]	3.10± 2.9

Dry season = Feb, March, April. Wet season= May, June, July. Total plate counts (TPC), Total coliform counts (TCC). W=sampling site. (abc) =column under both seasons are significantly different (p=0.05). Using Duncan's multiple range test ± =standard error.

The situation is particularly worrisome because of the heavy presence of waste materials which also continue to receive many more by the day. The wells close to such dump sites are likely to be under the influence of continuous pollution and such waste sites are physically unpleasant to eyes. The visual and odorous characteristics of the environment have the greatest impact upon the public's assessment of the water quality. The observations made revealed that the liter, rubbish (bottles, can, plastics, polythene waste, etc), and the runoff derived waste tend to negatively affect quality of water. Faeces could be seen around the wells, domestic waste could be seen discharged directly from residential houses into and around the wells. Both children and animals were seen to defecate and urinate around wells. There is also an increase count of heterotrophic counts during the wet season than the dry season possibly because of the increase in runoffs (Mark et al., 2001), reduced level of fetching and disturbance, and the increased availability of nutrients in the water. The higher growth rate of bacteria during the wet season when there is abundant nutrients will degenerate into nutrient depletion during the dry season leading to an increase in die-off rate (McCamdrige and McMeckin, 1980).

The volume of water is usually low with an over exploitation and excessive fetching. During the wet season, many waste materials from the surrounding waste are washed into these wells as runoffs or sipping without any available mechanism for runoff control to protect wells thereby increasing the coliform and aerobic plate counts. The average coliform count in the study ranged from $2.2x10^3$ to $7.3x10^3$cfu/ml in the dry season and from $1.38x10^3$ to $1.38x10^5$ cfu/ml in the wet season. Value that far exceed the WHO standard number of coliform per 100 ml of potable drinking water (WHO, 1984).

One factor that is thought to contribute to the occurrence of elevated number of coliform bacteria and other pathogens is bottom sediments. LeJeune et al. (2001) have implicated cattle and animal faeces as the main source of contamination of water, and have ascribed the high presence of *Escherichia coli* 0157 in surface water to human, cattle and other domestic animals. *Salmonella* and *E. coli* were isolated from nearly all the solid waste samples. Contamination of wells with faeces could lead to greater number of *Salmonella* and other indicator microorganisms being isolated (Goyal et al., 1977).

Bacteria of faecal origin have been shown to survive greater period of time in sediments than in overlaying water (Okafor et al., 2003).

Many investigations of drinking water associated disease have noted that heavy rainfall preceded the start of outbreaks, and that a higher dependence of rural

populations on untreated water for domestic activities in times of water scarcity, especially in the dry season when most wells are dry, could lead to a substantial increment in prevalence of waterborne diseases. Substantial shares of the total microbial load in well water and other drinking water reservoirs resulted from rainfall and extreme runoffs events.

Conclusion

In the light of the above results, the following conclusions can be drawn. All the wells showed a significant presence of coliform bacteria, indicating that animals and human waste are significant source of well water pollution. It is suggested that poor quality of well water in the study areas could be controlled by improving the sanitary and drainage systems and run-off. Absence of such control systems could lead to serious water quality problems in the areas. There is need for further investigations of wells on regular bases. The waste should be properly disposed for further accurate evaluation and level of waste spreading should be studied. Adequate treatments of well water as well as public health education are highly recommended.

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